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An undergraduate scholar in Electronics and Communication Engineering (ECE) at IIT ISM DHANBAD with hands-on experience in designing, C++, and embedded systems. Passionate about robotics, renewable energy, and electric vehicle technology. Eager to apply knowledge in solar energy integration and sustainable mobility solutions to create a positive impact on society.

A undergraduate scholar in Electrical Engineering at IIT ISM Dhanbad dedicated to pushing the boundaries of electric mobility and sustainable energy solutions. Skilled in C++, control systems and power electronics, with hands-on experience in renewable energy integration. Enthusiastic about designing efficient, high-performance electric vehicles that redefine urban transportation. Committed to leveraging creative problem-solving to contribute towards a greener, smarter, and more sustainable future.

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PROBLEM STATEMENT

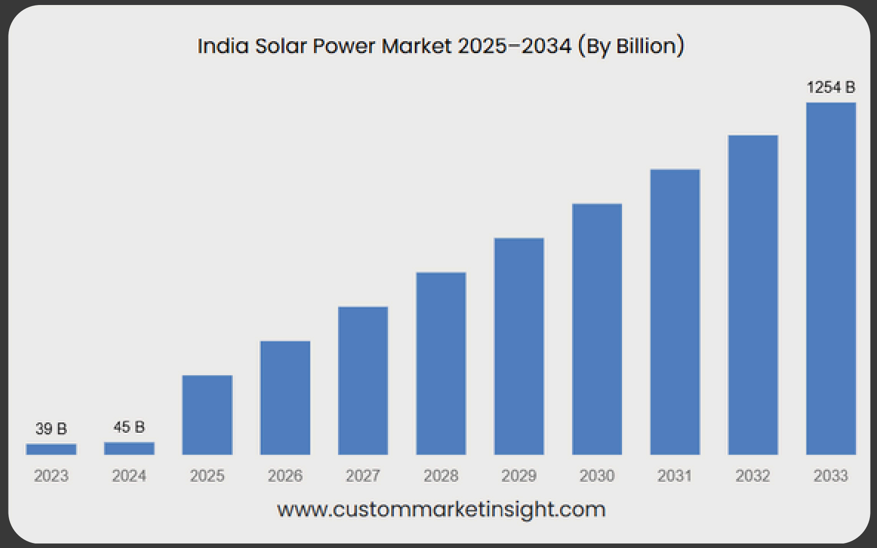
HOW CAN SOLAR PANELS BE EFFECTIVELY INTEGRATED INTO THREE-WHEELER EV'S TO MAXIMIZE ENERGY HARVESTING AND EXTEND BATTERY LIFE?

Limited Space
Three-wheelers have limited surface area for solar panels.

Variable solar energy generation
Depends on sunlight conditions.

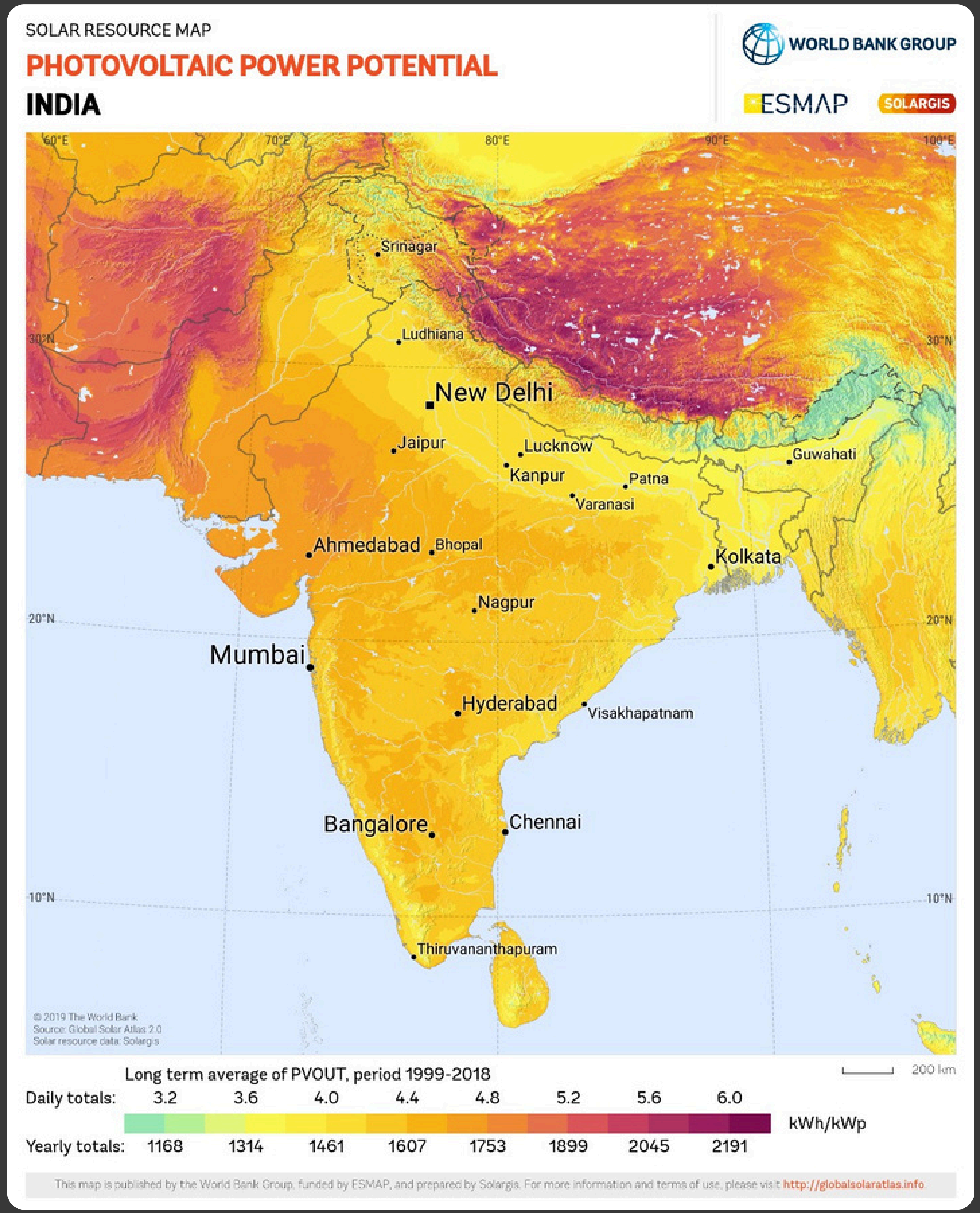
Cost-effectiveness of implementation.

SOLAR-POWERED EVS: MARKET GROWTH & ENERGY POTENTIAL



India is rapidly expanding its electric vehicle (EV) market, driven by government policies and increasing demand for sustainable transportation. With solar energy emerging as a key renewable source, integrating solar panels into EVs—especially three-wheelers—can enhance range and reduce grid dependency. The Indian solar power market is projected to grow at a CAGR of 41.5%, making it a viable energy solution for the future.

The graph comparing solar power generation and EV energy consumption is crucial for assessing the feasibility of solar-integrated three-wheelers. It helps identify the gap between solar energy supply and EV power demand, enabling manufacturers to optimize battery storage and panel efficiency. Policymakers can use this data to develop targeted incentives and prioritize high-yield solar regions for pilot projects, maximizing range extension and cost savings. Photovoltaic output, measured in kWh/kW/year, indicates a region's solar potential, guiding efficient energy planning for sustainable EV adoption.



OPTIMIZING SOLAR INTEGRATION FOR EFFICIENT THREE-WHEELER EVS

Analysis of key technical aspects related to efficient solar integration in an electric 3 wheeler (assumed to be an auto rickshaw):

Available Roof Area for Solar Panels ($\sim 1m^2$ on Auto-Rickshaws)

- The roof size of a standard auto-rickshaw is approximately 1.0m × 1.5m, making it feasible to install a $1m^2$ to $1.6m^2$ solar panel setup.
- For maximum efficiency ,a 1.5 kW solar panel system was used with a 1.6m × 1m panel dimension.

Solar Power Potential: 50W–300W Output

- The power output depends on solar irradiance and panel efficiency:
  - *Monocrystalline panels (Efficiency ~20%): Higher efficiency but costlier.*
  - *Polycrystalline panels (Efficiency ~15–18%): Cost-effective but lower efficiency.*
- A $1m^2$ panel can generate 150W–200W under ideal sunlight, while a $1.5m^2$ panel could generate 200W–300W.
- Under optimal conditions, solar energy could support 75 km of driving range per charge by supplementing the battery.

MPPT (Maximum Power Point Tracking) Increases Efficiency by 15-30%

- MPPT Controllers optimize solar power conversion, ensuring maximum energy is harvested.
- A buck converter and filtering circuit can be used to transfer energy to a 48V or 72V battery efficiently.
- Simulations showed that adjusting voltage and current through MPPT algorithms improved solar power utilization significantly.

Impact on Battery Life & Charging Needs

- The study shows that 72V, 90Ah lithium-ion battery pack, which takes ~7.81 hours to fully charge from a 1.5 kW solar panel.
- Battery life extension: Solar charging reduces the number of deep discharge cycles, extending the lifespan of the battery.
- Regenerative Braking Integration: Captures up to 70% of braking energy to further improve efficiency.

TECHNICAL SOLUTION: SOLAR PANEL INTEGRATION & ENERGY MANAGEMENT

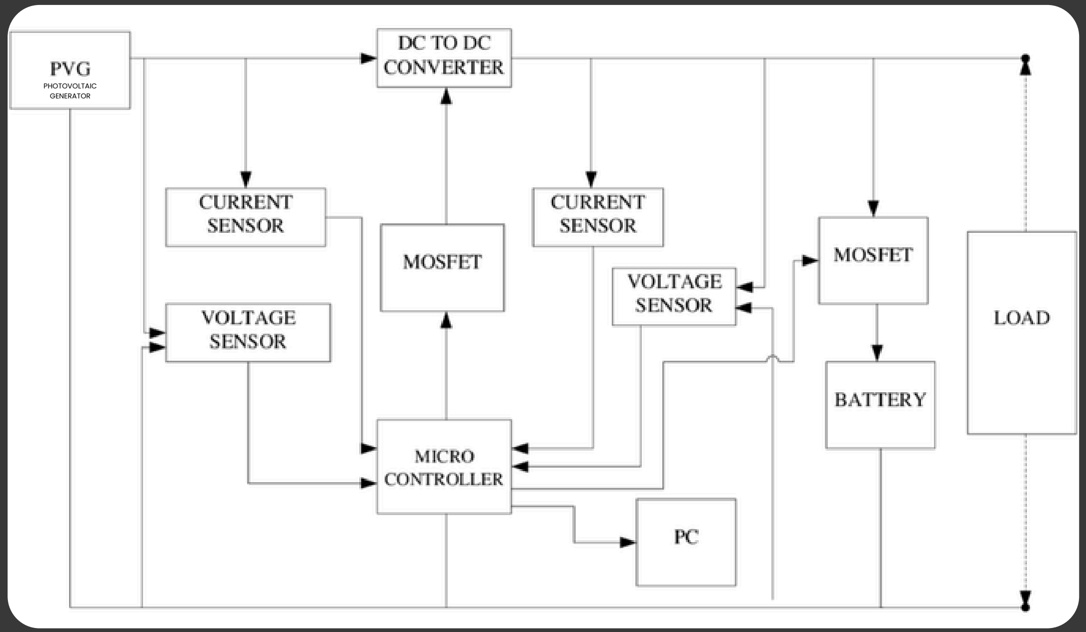
Solar Panel Integration Plan

- Panel Type: Flexible thin-film or polycrystalline panels for lightweight and cost-effective installation.
- Mounting Approach:
  - *Primary Roof Mounting (1m² – 1.5m² area).*
  - *Optional Foldable Side Panels to increase surface area when parked for charging.*
- Power Output:
  - *A 1.5 kW solar panel system (1.6m × 1m dimensions) was tested in research, indicating sufficient charging support.*
  - *Under ideal sunlight, it can generate up to 300W, reducing battery drain.*

Energy Management System

- MPPT Controller:
  - *Ensures maximum power extraction from solar panels.*
  - *Uses buck converter & filtering circuit to regulate voltage for efficient charging.*
- Direct Charging to Battery:
  - *Solar energy charges a 48V or 72V lithium-ion battery.*
  - *MPPT helps adjust input voltage to match battery requirements, minimizing losses.*
- Regenerative Braking Complementary System: Captures up to 70% of braking energy, further improving efficiency.

The block diagram depicts the solar energy flow in a solar-integrated three-wheeler. The photovoltaic generator (PVG) converts sunlight into electricity, regulated by a DC-DC converter for efficient charging. Sensors and a microcontroller optimize power management, while MOSFET switches control energy flow to the battery or load. This system improves efficiency, extends battery life, and reduces grid dependency, making solar-powered three-wheelers more sustainable.



EFFICIENCY MAXIMIZATION IN SOLAR-POWERED THREE-WHEELER EVS

Ideas to Boost Efficiency

- Tilt-Adjustable Solar Panels: Improves sunlight capture throughout the day, increasing power generation.
- Lightweight Materials: Reduces vehicle weight, improving energy efficiency and extending range.
- Smart Power Distribution: Prioritizes battery charging over auxiliary loads to maximize driving efficiency.
- Customizing the design of the solar panel to minimize aerodynamic drag will enhance the efficiency of solar-integrated electric vehicles

Expected Power Contribution

- The 1.5 kW solar panel system (1.6m × 1m) can generate enough energy to extend the vehicle's range by 5–10 km per day under optimal sunlight conditions.
- Regenerative Braking System: Captures up to 70% of braking energy, further improving efficiency.

Cost Consideration & ROI

- Estimated System Cost: ₹8,000 – ₹30,000 per vehicle for panel integration.
- ROI :
    - Reduces electricity charging costs.
    - Increases battery life by minimizing deep discharge cycles.
    - Saves fuel costs compared to petrol/diesel rickshaws.

RECOMMENDATION & FEASIBILITY OF SOLAR PANEL INTEGRATION IN THREE-WHEELER EVS

Final Recommendation

The integration of solar panels into three-wheeler EVs is both feasible and cost-effective, particularly for commercial applications such as urban transportation and last-mile connectivity. The research confirms that a 1.5 kW solar panel system can effectively supplement battery charging, reducing the dependency on grid electricity while promoting sustainability. However, solar panels should be used as a range extender rather than a complete replacement for traditional charging infrastructure.

Cost vs. Benefit Analysis

The initial investment for integrating solar panels (₹8,000 – ₹30,000 per vehicle) is recoverable within 2–3 years due to electricity cost savings and increased battery life. Additionally, the reduction in deep discharge cycles enhances battery longevity, further improving cost-effectiveness. Implementing Maximum Power Point Tracking (MPPT) technology increases solar efficiency by 15–30%, ensuring optimal energy utilization.

Implementation Strategy :

01

- Develop a working prototype with a 1.5 kW solar panel and MPPT-based battery charging.
- Conduct controlled efficiency and durability tests under various weather conditions.

02

- Deploy test vehicles in high solar irradiance locations like Rajasthan, Gujarat, and Maharashtra.
- Evaluate real-world energy savings, range extension, and operational feasibility.

03

- Scale up production and encourage commercial adoption by fleet operators.
- Seek government incentives and subsidies for increased affordability.

THANK YOU

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